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(54) PROJECTION OPTICAL SYSTEMMAGNIFICATION PROJECTION OPTICAL SYSTEMMAGNIFICATION PROJECTION APPARATUSAND IMAGE PROJECTION APPARATUS

(57)Abstract:
PROBLEM TO BE SOLVED: To provide a projection optical system capable of correcting chromatic aberrations as well while employing an imaging optical system inclusive of a reflection surface in order to reduce the projection space outside a projection apparatus while making a projection screen larger and an image projection apparatus using such projection optical system.
SOLUTION: First and second optical systems 17 and 19 are disposed in this order from the side of a light bulb 15 on the projection side of the light bulbThe first optical system 16 includes one or more dioptric system and has positive power. The second optical system 19 includes one or more reflection surface having the power and has the positive power. The image formed by the light bulb 15 is formed as an intermediate image Iint on optical paths of the first and second optical systems and the intermediate image Iint is further magnified and projected onto the screen 21.

CLAIMS

[Claim(s)]

[Claim 1]

In an image projection device which carries out enlargement projection of the picture which irradiated with illumination light from a light source a light valve which carries out image formation according to a modulating signaland was formed in the above-mentioned light valve according to a projection optical systemit is a projection optical system which carries out extended projection of the picture formed in the above-mentioned light valve

It has the 1st and 2nd optical systems allocated in the projection side of a light valve 1st and 2nd sequentially from the above-mentioned light-valve side

The 1st optical system of the above has positive power including one or more dioptric systems

The 2nd optical system of the above has positive powerincluding a reflector which has power one or more

A projection optical system carrying out image formation of the picture formed with the above-mentioned light valve as an intermediate image on an optical path of the 1st and 2nd optical systems of the aboveexpanding the above-mentioned intermediate image further and projecting it.

[Claim 2]

In the projection optical system according to claim 1

A projection optical system having an optical element with negative power for bringing close to a reflector with positive power [in / for an image formation position of an intermediate image / the 2nd optical system] in an optical-path top of the 1st and 2nd optical systems in the light-valve side of the above-mentioned intermediate image.

[Claim 3]

In the projection optical system according to claim 2

A projection optical system to which the 2nd optical system is characterized by having a reflector which has positive powerand a reflector which has negative power at least.

[Claim 4]

In a projection optical system given in 1 with arbitrary Claims 1-3

A projection optical systemwherein the 1st [or more] page of reflectors which the 2nd optical system has comprises a free sculptured surface.

[Claim 5]

In a projection optical system given in 1 with arbitrary Claims 1-4

A projection optical systemwherein a reflector with positive power which reflects light flux after intermediate image formation first is formed in a free sculptured surface.

[Claim 6]

In a projection optical system given in 1 with arbitrary Claims 1-5

A projection optical systemwherein the 1st optical system comprises only a dioptric system.

[Claim 7]
In 1 with arbitrary Claims 1-5
A projection optical systemwherein the 1st optical system comprises a reflector which has a symmetry axis of rotation inversionand a dioptric system.
[Claim 8]
In the projection optical system according to claim 6 or 7
A projection optical systemwherein a dioptric system has a refracting interface of aspherical surface shape.
[Claim 9]
In an image projection device which carries out enlargement projection of the picture which irradiated with illumination light from a light source a light valve which carries out image formation according to a modulating signaland was formed in the above-mentioned light valve according to a projection optical system
An image projection device having a thing of a description in 1 with arbitrary Claims 1-8 by making a picture formed in a light valve into a projection optical system which carries out extended projection.
[Claim 10]
It is an enlargement projection optical system to which image formation of the enlarged image of a picture which carried out the light guide of the light flux from a picture display panel to a screenprojected from a direction inclined to a normal of the above-mentioned screenand was displayed by described image display panel on the above-mentioned screen is carried out
It has a catoptric system and a transmitted light study system
The above-mentioned catoptric system is constituted by two or more reflectors with powerand includes the 1st [or more] page of a rotation unsymmetrical reflector
An enlargement projection optical systemwherein the above-mentioned transmitted light study system is constituted by transmission surface with refracting power and includes the 1st [or more] page of an aspheric surface.
[Claim 11]
In the enlargement projection optical system according to claim 10
An enlargement projection optical systemwherein an image of the above-mentioned diaphragm constitutes by an optical element which established a diaphragm from the picture display panel side in a transmitted light study system between the 1st page and the screen side in a catoptric systemand the 1st pageand has been arranged to the screen side so that image formation may be carried out with negative reducing magnification.
[Claim 12]
It is an enlargement projection optical system to which image formation of the enlarged image of a picture which carried out the light guide of the light flux from a picture display panel to a screenprojected from a direction inclined to a normal of the above-mentioned screenand was displayed by described image display panel on the above-mentioned screen is carried out

A transmitted light study system which consists of two or more transmission surfaces
A catoptric system which comprises two or more reflectors
It has a diaphragm
An enlargement projection optical systemwherein power of a reflector in which light flux which passed a diaphragm among reflectors in the above-mentioned catoptric system has the power which enters first is negative.
[Claim 13]
In the enlargement projection optical system according to claim 12
An enlargement projection optical systemwherein a reflector following a reflector in which light flux which passed a diaphragm has the negative power which enters first has positive power.
[Claim 14]
In the enlargement projection optical system according to claim 12 or 13
A catoptric system is constituted by two or more reflectors with powerand includes the 1st [or more] page of a rotation unsymmetrical reflector
An enlargement projection optical systemwherein a transmitted light study system is constituted by transmission surface with refracting power and includes the 1st [or more] page of an aspheric surface.
[Claim 15]
It is an enlargement projection optical system to which image formation of the enlarged image of a picture which carried out the light guide of the light flux from a picture display panel to a screenprojected from a direction inclined to a normal of the above-mentioned screenand was displayed by described image display panel on the above-mentioned screen is carried out
An enlargement projection optical systemwherein a position and form of an intermediate image of negative magnification of the above-mentioned screen which an intermediate image of negative magnification of a described image display panel which light flux from the picture display panel side to a screen generatesand light flux from the screen side to a picture display panel generate are abbreviated-in agreement.
[Claim 16]
In the enlargement projection optical system according to claim 15
A catoptric system which comprises two or more reflectors
An enlargement projection optical system having a transmitted light study system which consists of two or more transmission surfaces.
[Claim 17]
In the enlargement projection optical system according to claim 16
An enlargement projection optical systemwherein power of a reflector in which light flux which has a diaphragm and passed a diaphragm among reflectors in a catoptric system has the power which enters first is negative.
[Claim 18]
In the enlargement projection optical system according to claim 17

An enlargement projection optical systemwherein a reflector following a reflector in which light flux which passed a diaphragm has the negative power which enters first has positive power.

[Claim 19]

In an enlargement projection optical system given in 1 with arbitrary Claims 16–18

A catoptric system is constituted by two or more reflectors with powerand includes the 1st [or more] page of a rotation unsymmetrical reflector

An enlargement projection optical systemwherein a transmitted light study system is constituted by transmission surface with refracting power and includes the 1st [or more] page of an aspheric surface.

[Claim 20]

In an enlargement projection optical system given in 1 with arbitrary Claims 101114 and 19

An enlargement projection optical systemwherein a rotation unsymmetrical reflector has been most arranged in an incident light on the street at the screen side.

[Claim 21]

In Claims 10–14 and an enlargement projection optical system given in arbitrary 1 of 16–19

rotation for which a transmitted light study system has refracting power --- an enlargement projection optical system including an unsymmetrical transmission surface.

[Claim 22]

In Claims 10–14 and an enlargement projection optical system given in arbitrary 1 of 16–21

An enlargement projection optical systemwherein an optic axis of a transmitted light study system carries out eccentricity and is set up to a picture display panel position in a field including a light guide optical path.

[Claim 23]

In Claims 10–14 and an enlargement projection optical system given in arbitrary 1 of 16–22

An enlargement projection optical systemwherein the above-mentioned catoptric system is constituted as a unit.

[Claim 24]

Display a picture on a picture display panelilluminate a described image display panel with light from a light sourcecarry out the light guide of the light flux from an illuminated picture display panel to a screen according to an enlargement projection optical systemand it projects from a direction inclined to a normal of the above-mentioned screenIt is enlargement projection equipment which projects an enlarged image of a picture displayed on a described image display panel on the above-mentioned screen

Enlargement projection equipment using an enlargement projection optical system of a description for 1 with arbitrary Claims 10–23 as an enlargement projection optical system.

[Claim 25]

The 1st optical system that has positive power including at least one dioptric system

It has the 2nd optical system that has positive power on the whole including at least one reflector which has power

It is arranged in order of the 1st and 2nd optical system from a side near an object face

It is constituted so that image formation may be carried out as a regular image once an object image is formed as an intermediate image
A projection optical system to which other optical elements are characterized by parallel eccentricity and/or carrying out tilt eccentricity at one or more places to an optic axis of an optical element which had the refracting power nearest to the object side in the 1st optical system of the above.
[Claim 26]
The 1st optical system that has positive power including at least one dioptric system
It has the 2nd optical system that has positive power on the whole including at least one reflector which has power
It is arranged in order of the 1st and 2nd optical system from a side near an object face
It is constituted so that image formation may be carried out as a regular image once an object image is formed as an intermediate image
A projection optical systemwherein each element of the 1st optical system of the above has not carried out tilt eccentricity to an optic axis of an optical element which had the refracting power nearest to the object side in the 1st optical system of the above.
[Claim 27]
In the projection optical system according to claim 26
A projection optical systemwherein the 1st optical system comprises two or more groups and at least one of two or more [above] groups is carrying out parallel eccentricity.
[Claim 28]
In a projection optical system given in 1 with arbitrary Claims 25–27
A projection optical systemwherein one or more [of a reflector included in the 2nd optical system] is a free sculptured surface.
[Claim 29]
In the projection optical system according to claim 28
A projection optical system making into a free sculptured surface only a reflector nearest to the image formation position side of a regular image among reflectors included in the 2nd optical system.
[Claim 30]
In a projection optical system given in 1 with arbitrary Claims 25–29
A projection optical systemwherein light flux which entered into the 2nd optical system makes a reflector which has the first positive power to be reflected a field symmetrical with rotation.
[Claim 31]
In the projection optical system according to claim 30
A projection optical systemwherein a reflector symmetrical with rotation is a surface-of-a-sphere reflector.
[Claim 32]
In a projection optical system given in 1 with arbitrary Claims 25–31
A projection optical systemwherein the 1st optical system comprises only a dioptric system.

[Claim 33]
In the projection optical system according to claim 32
A projection optical systemwherein aspherical surface shape is not included in a dioptric system in the 1st optical system.
[Claim 34]
It is an image projection device to which image formation of the regular image of a picture which carried out the light guide of the light flux from a picture display panel to a screen according to a projection optical systemand was displayed by described image display panel on the above-mentioned screen is carried out
An image projection device carrying a projection optical system of a description in 1 with arbitrary Claims 25-33 as a projection optical system.
[Claim 35]
It is a projection optical system which carries out the light guide of the light flux from a projection object sideand projects it on a surface of projection via a transmission type dioptric system and a reflection type dioptric system which comprises 1 or two reflective mirrors
A transmission type dioptric system has two or more transmission type refraction elements from a projection object side up to the 1st page of the above-mentioned transmission type dioptric system -- an abbreviated call -- centric
An intermediate image surface of the above-mentioned projection object side is locatedand re-image formation of the intermediate image in the above-mentioned intermediate image surface is carried out to the reflection type dioptric system side as a regular image on a surface of projection via the above-mentioned reflective mirror rather than a transmission type dioptric system
At least one reflective mirror is an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction
From the above-mentioned reflection type dioptric systemto a normal of the above-mentioned surface of projectiona beam of light which reaches the above-mentioned surface of projection inclinesand a light guide is carried out
A projection optical systemwherein two or more transmission type refraction elements which carry out eccentricity of the above-mentioned transmission type dioptric system to a normal of a projection object sideand the above-mentioned transmission type dioptric system has are constituted without carrying out eccentricity mutually.
[Claim 36]
It is a projection optical system which carries out the light guide of the light flux from a projection object sideand projects it on a surface of projection via a transmission type dioptric system and a reflection type dioptric system which comprises 1 or two reflective mirrors
A transmission type dioptric system has two or more transmission type refraction elements from a projection object side up to the 1st page of the above-mentioned transmission type dioptric system -- an abbreviated call -- centric

An intermediate image surface of the above-mentioned projection object side is locatedand re-image formation of the intermediate image in the above-mentioned intermediate image surface is carried out to the reflection type dioptric system side as a regular image on a surface of projection via the above-mentioned reflective mirror rather than a transmission type dioptric system
At least one reflective mirror is an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction
From the above-mentioned reflection type dioptric systemto a normal of the above-mentioned surface of projectiona beam of light which reaches the above-mentioned surface of projection inclinesand a light guide is carried out
A projection optical systemwherein two or more transmission type refraction elements which carry out eccentricity of the above-mentioned transmission type dioptric system to a normal of a projection object sideand the above-mentioned transmission type dioptric system has comprise a group unit levelwithout carrying out eccentricity mutually.
[Claim 37]
In the projection optical system according to claim 35 or 36
A ****** type dioptric system has two reflective mirrors arranged 1st and 2nd sequentially from the transmission type dioptric system side
An intermediate image surface of a projection object side is located between the above 1st and the 2nd reflective mirror
A reflector where a reflective mirror of the above 1st is symmetrical with an axis of negative powera projection optical systemwherein a reflective mirror of the above 2nd is an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction.
[Claim 38]
In Claim 35 or a projection optical system given in 36 or 37
As a means to amend an aspect ratio of an intermediate image of a projection object side
A projection optical system having an anamorphic polynomial free sculptured surface from which power differs in a transmission type dioptric system in a sliding direction and a longitudinal direction.
[Claim 39]
In a projection optical system given in 1 with arbitrary Claims 35-38
A projection optical system to which NA by the side of a projection object side in a transmission type dioptric system is characterized by being larger than NA by the side of an intermediate image surface.
[Claim 40]
In a projection optical system given in 1 with arbitrary Claims 35-39
A projection optical systemwherein an intermediate image surface is carrying out the inclination curve to a chief ray of light flux ejected from the center of a projection object side.
[Claim 41]

In a projection optical system given in 1 with arbitrary Claims 35–40
A projection optical system characterized by a chief ray ejected from the center of a projection object side and a chief ray ejected from the circumference of the above–mentioned projection object side being almost parallel in a final surface of a transmission type dioptric system.
[Claim 42]
In a projection optical system given in 1 with arbitrary Claims 35–41
Magnification of an intermediate image: A projection optical system setting M1 to 1–5.
[Claim 43]
In a projection optical system given in 1 with arbitrary Claims 35–42
A projection optical system making projecting magnification or more into 40.
[Claim 44]
In the projection optical system according to claim 43
The degree of angle of projection to a surface of projection: A projection optical system to which theta is characterized by being larger than 5 degrees.
[Claim 45]
It is an image projection device which carries out extended projection of the picture displayed on a projection object side on a surface of projection according to a projection optical system
An image projection device using a thing of a description for 1 with arbitrary Claims 35–46 as a projection optical system.
[Claim 46]
In the image projection device according to claim 45
An image projection device being a front projector type.
[Claim 47]
In the image projection device according to claim 45
They are the feature and ********** about it having a clinch mirror which turns up an image formation optical pathand being a rear projector type.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[Field of the Invention]
[0001]
This invention relates to a projection optical systeman enlargement projection optical systemenlargement projection equipmentand an image projection device.
[Background of the Invention]
[0002]
These daysan improvement of the luminosity accompanying high–resolution–izing of a liquid crystal panel and efficient–izing of a light source lamplow–pricingetc. are following the liquid

crystal projector widely known as an image projection device.
The small lightweight image projection device using DMD (Digital Micro-mirror Device) spreadsand these image projection devices are widely used increasingly also not only at an office or a school but at a home. Portability of a projector [especially / front type] improves and it is increasingly used also for the small meeting of several person scale.
[0003]
The projector which is an image projection device is requested to be able to make as small as possible "projection space needed out of a projector" with the ability of the picture of a big screen to be projected (big-screen-izing of a projection picture plane).
[0004]
In order to reduce the projection space besides a projectorattaining big screen-ization of a projection picture planethat of "marching in to the inside of an image projection device" is good as much as possible in the optical path of the image formation light flux which carries out image formation of the picture on which it is projectedand the thing of the patent documents 1 - five descriptions is known as an image projection device which performed such a device.
[0005]
In order that the image projection device of patent-documents 1 description may suppress enlargement of an image formation optical system and may attain wide field angle-izationit is provided with the 1st - the 4th reflectormakes a convex a concave configurationthe 2nd - the 4th reflector for the 1st reflectorand constitutes the image formation optical system with these reflectors. Reservation of projection performance is aimed at by making the 1st [at least] page in the 1st - the 4th reflector into free sculptured surface form.
[0006]
The image projection device of patent-documents 2 description is the field projection type display which shortened projector distance to a screen.
The pair of a concave mirror and "the convex mirror which has transpiration"and the projector lens constitute the image formation optical system.

[0007]
The image projection device of patent-documents 3 description is a "video projector"makes convex form the 1st mirror plane in an image formation optical systemand is attaining slimming down of equipment.
[0008]
In the image projection system indicated to the patent documents 1 and 3although enlargement projection of the picture of a light valve is carried out on a screenonly the reflector is performing image formationand there is a merit that a chromatic aberration does not occur theoretically. Howeverin displaying red and a green and blue picture on three light valves separately like 3 board types instead of a single plate type and combining each picture on a screenit is necessary to make the color synthesizing means of a cross prismthe Philips prismetc. interveneand a chromatic aberration occurs in the case of color compositionbut. In

the image formation optical system only by a reflectorchromatic aberration correction is impossible.

[0009]

In the image projection device of patent-documents 4 descriptiona light guide is carried out to a screen one by one according to the enlargement projection optical system by the imaging lens system which has positive power for the light flux from a picture display paneland the catoptric system containing the curved surface mirror of negative powerand image formation is carried out.

[0010]

The height and imaging lens system of a screen shift heightare set upare turned up by a mirrorand a light guide is carried out to a screen. For this reasonwith the projection expansion picture the upper part and the bottom of the central part (it corresponds to the central part of a picture display panel) on a screenthe light path length of image formation light flux differsand what is called a "keystone distortion" occurs as that result.

[0011]

Although "keystone amendment" can amend a keystone distortionkeystone amendment tends to bring about image quality degradation of the expansion picture on a screen.

[0012]

****** "carries out eccentricity of the convex mirror to the optic axis of an image formation lensand provides it" between an imaging lens system and a screen is known by considering a keystone distortion as the composition to lessen. When carrying out eccentric arrangement of the convex mirrora convex mirror is arranged "for it to be an image formation lens side from the screen side focal position"and the focal position of a projector lens is lengthened by the negative refracting power which a convex mirror has. [of an imaging lens system]

[0013]

Although there is the method of enlarging negative power of a convex mirror and extending a field angle with such compositionalthough a thin shape and the enlargement projection equipment of a big screen are realizedthe accuracy of form and the common difference with a group of a convex mirror become severeand distortion also becomes large.

[0014]

Although refracting power of a convex mirror can be weakened and distortion can be reduced by enlarging distance between an image formation lens and a convex mirrorin connection with the distance of an image formation lens and a convex mirror becoming largea convex mirror is enlargedand the cost of a mirror becomes high and it is easy to enlarge enlargement projection equipment.

[0015]

The enlargement projection optical system is constituted from the patent documents 5 by only the reflective mirror. thusif it is going to obtain desired optical performancewithout using a lens optical systemset up very highly the profile irregularity and accuracy of position of each reflectorand an enlargement projection optical system should grapple — accuracy becomes severe.

[0016]
[Patent documents 1] Provisional publication of a patent 2002 – 40326
[Patent documents 2] JP2002-174853A
[Patent documents 3] JPH6-91641B
[Patent documents 4] JP2001-264627A
[Patent documents 5] JP2002-296503A
[Description of the Invention]
[Problem to be solved by the invention]
[0017]
In order to reduce the projection space besides a projection devicethis invention being made in view of the situation mentioned aboveand attaining big screen-ization of a projection picture planeLet realization of the image projection device using the projection optical system which can also amend a chromatic aberrationan enlargement projection optical systemenlargement projection equipmentsuch a projection optical systemetc. be SUBJECTadopting an image formation optical system including a reflector.
This invention makes it SUBJECT for it to be distorted and to enable it to project a big screen that there is nothing again while slimming down an image projection device.
[Means for solving problem]
[0018]
The projection optical system according to claim 1 In an image projection device which carries out enlargement projection of the picture which irradiated with illumination light from a light source a light valve which carries out image formation according to a modulating signal, and was formed in a light valve according to a projection optical system, It is a projection optical system which carries out extended projection of the picture formed in a light valveand has the following features.
[0019]
That isit has the 1st and 2nd optical systems allocated in the projection side (the advance side of projection luminous flux) of a light valve 1st and 2nd sequentially from the light-valve side.
The 1st optical systemhas positive power including one or more dioptric systems.
The 2nd optical systemhas positive powerincluding a reflector which has power one or more.
By operation of the 1st and 2nd optical systemsimage formation of the picture formed with a light valve is once carried out as an "intermediate image" on an optical path of the 1st and 2nd optical systemsthis intermediate image is expanded further and it is projected on it on display surfacessuch as a screen.
[0020]
In the projection optical system according to claim 1it can have an optical element which has the negative power for "bringing close to a reflector with positive power [in / for an image formation position of an intermediate image / the 2nd optical system]" on an optical path of the 1st and 2nd optical systems in "the light-valve side of an intermediate image" (Claim 2).
In this casewhat the 2nd optical system "has a reflector which has positive powerand a

reflector which has negative power for" at least is made (Claim 3).
[0021]
In a projection optical system given in 1 with the above-mentioned arbitrary Claims 1-3the 1st [or more] page of the reflectors which the 2nd optical system has can consist of free sculptured surfaces (Claim 4).
It is preferred to form "a reflector with the positive power which reflects the light flux after intermediate image formation first" in 1 with arbitrary Claims 1-4 in the projection optical system of a description in a free sculptured surface (Claim 5).
[0022]
In a projection optical system given in 1 with the above-mentioned arbitrary Claims 1-5the 1st optical system can also constitute only a "dioptric system" and can also consist of "the reflectors and dioptric systems which have a symmetry axis of rotation inversion" (Claim 7). (Claim 6)
[0023]
In a projection optical system these Claim 6 or given in seventhe dioptric system can have "a refracting interface of aspherical surface shape" as a free sculptured surface (Claim 8).
[0024]
The image projection device of this invention "to the light valve which carries out image formation according to a modulating signal. It irradiates with the illumination light from a light sourceand it is an image projection device which carries out enlargement projection of the picture formed in the light valve according to a projection optical system"is considered as the projection optical system which carries out extended projection of the picture formed in the light valveand has a thing of a description in 1 with arbitrary Claims 1-8 (Claim 9).
[0025]
The enlargement projection optical system according to claim 10 is "an enlargement projection optical system to which image formation of the enlarged image of a picture which carried out the light guide of the light flux from a picture display panel to a screenprojected from a direction inclined to a normal of a screenand was displayed by picture display panel on a screen is carried out."
[0026]
Picture display panelsis light valves (LV)such as a transmission type and reflection type various liquid crystal panelsa digital micro mirror device (DMD)etc.
[0027]
The enlargement projection optical system according to claim 10 has the feature like the following.
That isan enlargement projection optical system has a catoptric system and a transmitted light study system.
A "catoptric system" is constituted by two or more reflectors with powerand includes the 1st [or more] page of a rotation unsymmetrical reflector. A "rotation unsymmetrical reflector" is a reflector in which form of a reflector does not have a symmetry axis of rotation inversion.

A "transmitted light study system" is constituted by transmission surface with refracting powerand includes the 1st [or more] page of an aspheric surface.

[0028]

In this enlargement projection optical system according to claim 10 "by an optical element which established a diaphragm from the picture display panel side in a transmitted light study system between the 1st page and the screen side in a catoptric systemand the 1st pageand has been arranged to that screen side. What an image of the above-mentioned diaphragm constitutes so that image formation may be carried out with negative reducing magnification" is preferred (Claim 11).

[0029]

The enlargement projection optical system according to claim 12 has the feature like the following.

That isit has "a transmitted light study system which consists of two or more transmission surfaces"a catoptric system which comprises two or more reflectorsand a "diaphragm"and power of the reflectors "reflector in which light flux which passed a diaphragm has the power which enters first" in a catoptric system is negative.

[0030]

In this enlargement projection optical system according to claim 12it is preferred that a reflector following "a reflector in which light flux which passed a diaphragm has the negative power which enters first" has positive power (Claim 13).

[0031]

a catoptric system in the enlargement projection optical system according to claim 12 or 13 is constituted by two or more reflectors with "power -- a rotation unsymmetrical reflector -- 1st [or more] page **" -- seeing -- a transmitted light study system -- "-- it is constituted by transmission surface with refracting powerand more than 1 page **" ****** is preferred in an aspheric surface (Claim 14).

[0032]

The enlargement projection optical system according to claim 15 has the feature like the following.

Namelyan intermediate image of negative magnification of a picture display panel which light flux from the picture display panel side to a screen generates (intermediate image of an image panel generated on an optical path of image formation light flux by an enlargement projection optical system)An intermediate image of negative magnification of a screen which light flux from the screen side to a picture display panel generates (intermediate image of a screen generated on the above-mentioned optical path when entering light in an enlargement projection optical system from the screen side virtually.) Incidentally position and form of an image of a screen at this time which carries out image formation on a picture display panel by a reduced image abbreviated-correspond.

[0033]

Can have this enlargement projection optical system according to claim 15 (Claim 16)and "a catoptric system which comprises two or more reflectors"and "a transmitted light study

system which consists of two or more transmission surfaces" in this caseAn enlargement projection optical system has a "diaphragm" and can make negative power of the reflectors "reflector in which light flux which passed a diaphragm has the power which enters first" in a catoptric system (Claim 17). In this caseit is preferred that "a reflector following a reflector in which light flux which passed a diaphragm has the negative power which enters first" has positive power (Claim 18).

[0034]

In an enlargement projection optical system given in 1 with arbitrary Claims 16-18A catoptric system can be considered as "composition which is constituted by two or more reflectors with powerand includes the 1st [or more] page of a rotation unsymmetrical reflector"and a transmitted light study system can be considered as "composition which is constituted by transmission surface with refracting power and includes the 1st [or more] page of an aspheric surface" (Claim 19).

[0035]

In an enlargement projection optical system given in 1 with the above-mentioned arbitrary Claims 101114 and 19it is preferred that a "rotation unsymmetrical reflector" included in a catoptric system is most arranged in an incident light on the street at the screen side (Claim 20).

[0036]

rotation as for which a transmitted light study system has "refracting power in the above-mentioned Claims 10-14 and an enlargement projection optical system given in arbitrary 1 of 16-19 --- it is preferred that unsymmetrical transmission surface" is included (Claim 21).

[0037]

In the enlargement projection optical system of a descriptionto Claims 10-14 and arbitrary 1 of 16-21the optic axis of a transmitted light study systemTo a picture display panel positionin a field including a light guide optical path (optical path of the chief ray from the center of a picture display panel to the center of the enlarged image on a screen in the optical path from a picture display panel to a screen)eccentricity is carried out and it can be set up (Claim 22).

[0038]

The catoptric system in the above-mentioned Claims 10-14 and an enlargement projection optical system given in arbitrary 1 of 16-22 can be constituted as a "unit" (Claim 23).

[0039]

The enlargement projection equipment according to claim 24 A picture is displayed on a picture display panel, Illuminate a picture display panel with the light from a light source, carry out the light guide of the light flux from the illuminated picture display panel to a screen according to an enlargement projection optical system, and it projects from the direction inclined to the normal of a screen, It is enlargement projection equipment which projects on a screen the enlarged image of the picture displayed on the picture display paneland the enlargement projection optical system of the description was used for 1 with arbitrary Claims 10-23 as an enlargement projection optical system.

[0040]
When supplemented a little about the invention according to claim 10 to 24not only a lens side but an Fresnel lens face may be sufficient as the "transmission surface" included in the "transmitted light study system" explained above.
The composition a reflection of the light in the reflector included in a catoptric system "fulfills total-internal-reflection conditions" may be used. Thuswhen making a reflector into a "total-internal-reflection side"the field which incorporates the light flux from a transmitted light study systemis a transmission surface. In this caseif a field and the light flux incidence to this transmission surface are made to cross at right anglessince aberration will not occur in the case of incidenceit is desirable.
[0041]
The "picture display panel" used for enlargement projection equipment is not restricted to one sheet. Using the picture display panel of three sheetsdisplay each color component image of R (red)G (green)and B (blue) on "a different picture display panel" for every colorand the light from these picture display panels is compoundedA light guide is carried out to a screen according to an enlargement projection optical systemand it cannot constitute also until it saysso that a color picture may be displayed on a screen.
[0042]
In the enlargement projection optical system of this inventionimage formation light flux is projected from the direction leaning to the screen method lineSince image formation is carried out on a screendistortion of the display image produced when projecting from the direction of a screen method line, and image formation light flux inclines to a screen method linecan be made to reduce effectively.
[0043]
Realization according [the transmission surface with the refracting power of a transmitted light study system] to a lens system is easyand the cost cut effect is acquired that cell-izing is also easy and it is easy to take out attachment accuracy. The rotation unsymmetrical reflector included in a catoptric system can amend an unsymmetrical aberration component.
[0044]
Since the arrangement of the refracting interface is extended in the one direction if an enlargement projection optical system is constituted only from a refracting interfacethree-dimensional structure of an optical system cannot be miniaturizedbut with the combination of a transmission surface and a reflectorthe composition which turns up an optical path can be taken and an optical system can be miniaturized.
[0045]
For exampleif the optical path of a transmitted light study system is set as a screen and parallel and an optical path is bent to the screen side by the image side of a transmitted light study systemthin composition is realizable also by the same light path length's optical system.
[0046]
Like the enlargement projection optical system according to claim 10arrange a diaphragm between the 1st page by the side of the picture display panel in a transmitted light study

systemand the 1st page by the side of the screen in a catoptric systemand according to the light flux from the panel side. If image formation of the image of a diaphragm is carried out once in all the optical systemsthe image formation position of a diaphragm image will serve as an exit pupil by the side of a screen. The image of a diaphragm is a real image and has negative reducing magnification. The beam-of-light effective diameter of the reflector after a diaphragm image is stopped smalland a reflector can be miniaturized because it is made to carry out image formation of the image of a diaphragm with reducing magnification.

[0047]

A diaphragm can be arranged "between a transmitted light study system and the catoptric system in a transmitted light study system." "The reflector with power" into which the light which passed the diaphragm enters first is in a catoptric system. It is difficult to unify a catoptric system and a transmitted light study systemand a transmitted light study system and a catoptric system are attached independently. Since an attachment error accompanies each of a transmitted light study system and a catoptric system at this timeit is difficult to carry out zero of the "relative position gap" of both optical systems thoroughlyand when premised on generating of a relative position gapit is good [the viewpoint of common difference sensitivity to the above "reflector with power"] that it is a reflector of negative power.

[0048]

Cases where light flux ejected from a transmitted light study system is a sending light bunch are rareand are usually condensed. If power of a field which has the power first reflected in a catoptric system at this time is made positiveit will act in the direction by which condensing of light flux is strengthened. On the other handif power of the above-mentioned field is made negativeit will act in the direction which condensing of light flux can loosen. when both are compared "change of a light flux state by relative location gap of a transmitted light study system and a catoptric system"be large in the former and grapple --- common difference becomes severe. It attaches by making power of the above-mentioned reflector negativeand common difference can be made loose.

[0049]

If a reflector which has positive power following a reflector with the above-mentioned negative power is allottedseparation of light flux from which a field angle differs can be controlledand a reflector which receives such light flux can be miniaturized.

[0050]

By what "it extracts and form and a position of an intermediate image of a screen are abbreviated-coincided for" like the invention according to claim 15the sum of a distortion aberration from a picture display panel to an intermediate image and a distortion aberration from an intermediate image to a screen can be brought close to 0and few images can be formed on a screen.

[0051]

Like the invention according to claim 20if a final surface on an image formation optical path is made into a rotation unsymmetrical reflectorflexibility of face shape corresponding to an

irradiation position of each light flux will become high. Amendment becomes easy by giving form where it was suitable for every incidence position in a residual aberration of light flux of each image height position which reaches this final surface.

[0052]

the invention according to claim 21 — like — a transmitted light study system — rotation — if an unsymmetrical transmission surface is usedin a transmission surface symmetrical with rotationaberration which could be made to generate aberration which cannot be generated and was generated in this way can be used for cancellation of other aberration.

[0053]

If eccentricity of the optic axis of a transmitted light study system is carried out and it is set up to a picture display panel position like the invention according to claim 22 in a field including a light guide optical pathaberration contrary to aberration generated in an eccentric reflector in a catoptric system can be generated by a transmitted light study systemand both can be made to cancel.

[0054]

The projection optical system according to claim 25 has the 1st and 2nd optical systems. The 1st optical systemhas positive power including at least one dioptric system.

[0055]

The 2nd optical systemhas positive power on the whole including at least one reflector which has power.

[0056]

These 1st and 2nd optical systems are constituted so that image formation may be carried out as a regular image once an object image arranged in order of the 1st and 2nd optical system from a side near an object face is formed as an intermediate image.

[0057]

The projection optical system according to claim 25 has the feature like the following. namely-- in the 1st optical systemother optical elements set to one or more places to an optic axis of "an optical element with refracting power nearest to the object side" — parallel eccentricity — and/ortilt eccentricity is carried out. That isparallel eccentricity or tilt eccentricity is performed "per optical element."

[0058]

The projection optical system according to claim 26 has the 1st and 2nd optical systems. The 1st optical systemhas positive power including at least one dioptric system.

[0059]

The 2nd optical systemhas positive power on the whole including at least one reflector which has power.

[0060]

These 1st and 2nd optical systems are constituted so that image formation may be carried out as a regular image once the object image arranged in order of the 1st and 2nd optical system from the side near an object face is formed as an intermediate image.

[0061]

The projection optical system according to claim 26 has the feature like the following. That isin the 1st optical systemtilt eccentricityof each element of the 1st optical system has not been carried out to the optic axis of "an optical element with the refracting power nearest to the object side."

[0062]

In this projection optical system according to claim 26it can have "composition which constituted the 1st optical system from two or more groups and to which parallel eccentricity of at least one of two or more groups was carried out" (Claim 27).

[0063]

In a projection optical system given in 1 with arbitrary Claims 25–27it is preferred to make into a "free sculptured surface" one or more [of the reflector included in the 2nd optical system] (Claim 28). In this casethe inside "reflector nearest to the image formation position side of a regular image" of the reflector included in the 2nd optical system can be made into a free sculptured surface (Claim 29).

[0064]

It is preferred to make "the reflector which has the first positive power for the light flux which entered into the 2nd optical system to be reflected in" into a field symmetrical with rotation in the projection optical system of a description 1 with arbitrary Claims 25–29 (Claim 30). In this casea reflector symmetrical with rotation can be made into a "surface-of-a-sphere reflector" (Claim 31).

[0065]

In the projection optical system of a descriptionit can carry out "constituting the 1st optical system only from a dioptric system" to 1 with arbitrary Claims 25–31 (Claim 32). in this caseaspherical surface shape is not included inthe dioptric system in the 1st optical system — it can do like (Claim 33).

[0066]

The image projection device according to claim 34 is the regular image of the picture which carried out the light guide of the light flux from a picture display panel to the screen according to the projection optical systemand was displayed by the picture display panel on the screen an image projection device which carries out image formationand as a projection optical systemThe projection optical system of the description was carried in 1 with arbitrary Claims 25–33.

[0067]

In the image projection device using the projection optical system indicated to Claims 25–33 when supplemented a little per [which was indicated to the above-mentioned Claims 25–34] inventionAs an object which displays the object image on which it is projectedlike light valvessuch as a liquid crystal panelor DMD and a slide filmIt cannot be overemphasized that self-luminescence type image display meanssuch as what arranged the light emitting diode in two dimensionsa plasma displayand an EL light emitting element arraycan be used as well as the ability to use the image display means of the system illuminated with the light from an external light source.

[0068]
The "dioptric system" can also be "a light transmission type element which shows a diffraction operation" in addition to a lens.
[0069]
The projection optical system according to claim 35 is "a projection optical system which carries out the light guide of the light flux from a projection object sideand projects it on a surface of projection via a transmission type dioptric system and the reflection type dioptric system which consists of 1 or two reflective mirrors"and has the feature like the following.
[0070]
A "transmission type dioptric system" has two or more transmission type refraction elements.
[0071]
The "transmission type refraction element" can also be "a light transmission type element which shows a diffraction operation" in addition to italthough "the optical element at large which shows an optical refraction operation in the interface of a light transmittance state medium" is meant and a typical element is a lens.
[0072]
The reflective mirror which makes a "reflection type dioptric system" can mean the optical element at large which shows the reflective refractive action of the light in a reflecting boundaryand can also be "a light reflex type optical element which shows a diffraction operation."
[0073]
from a projection object side up to the 1st page of the above-mentioned transmission type dioptric system — an abbreviated call — it is centric.
[0074]
Although the picture which should be projected is a field displayed as an objecta "projection object side"What makes the substance of this field like light valvessuch as a liquid crystal panel mentioned aboveor DMD and a slide filmThe image display means of the system illuminated with the light from an external light source can be usedand what arranged the light emitting diode in two dimensionsa plasma displayan EL light emitting element arrayetc. can use a self-luminescence type image display means further.
[0075]
An intermediate image surface of a projection object side is locatedand re-image formation of the intermediate image in an intermediate image surface is carried out to the reflection type dioptric system side as a regular image on a surface of projection via a reflective mirror rather than a transmission type dioptric system.
[0076]
at least one reflective mirror (a time of a reflection type dioptric system being constituted by one reflective mirror — the reflective mirror concerned.) When a reflection type dioptric system comprises two reflective mirrorsone or more reflective mirrors are anamorphic polynomial free sculptured surfaces from which power differs in a sliding direction and a

longitudinal direction.
To a normal of a surface of projectiona beam of light from a reflection type dioptric system to a surface of projection inclinesand a light guide is carried out.
[0077]
Eccentricity of the transmission type dioptric system is carried out to a normal of a projection object sideand two or more transmission type refraction elements which a transmission type dioptric system has are constitutedwithout carrying out eccentricity mutually.
[0078]
The projection optical system according to claim 36 Light flux from a projection object side A transmission type dioptric system, It is a projection optical system which carries out a light guide and is projected on a surface of projection via a reflection type dioptric system which comprises 1 or two reflective mirrorsa transmission type dioptric system has two or more transmission type refraction elements -- from a projection object side up to the 1st page of a transmission type dioptric system -- an abbreviated call -- it being centric andAn intermediate image surface of a projection object side is located in the reflection type dioptric system side rather than a transmission type dioptric systemRe-image formation of the intermediate image in an intermediate image surface is carried out as a regular image on a surface of projection via a reflective mirrorand at least one reflective mirror in an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction. A beam of light of a point by which a light guide is carried out by inclining to a normal of a surface of projection from a reflection type dioptric system to a surface of projection is the same as that of the projection optical system according to claim 35.
[0079]
When considering it as the feature of the projection optical system according to claim 36it is in a point "a transmission type dioptric system carries out eccentricity to a normal of a projection object sideand two or more transmission type refraction elements which a transmission type dioptric system has comprise a group unit level without carrying out eccentricity mutually."
[0080]
A projection optical system above-mentioned Claim 35 or given in 36 "a ****** type dioptric systemIt has two reflective mirrors arranged 1st and 2nd sequentially from the transmission type dioptric system sideIt can be an anamorphic polynomial free sculptured surface with which an intermediate image surface of a projection object side is located between the 1st and 2nd reflective mirrorsand power differs between a reflector where the 1st reflective mirror is symmetrical with an axis of negative powerand the 2nd reflective mirror in a sliding direction and a longitudinal direction (Claim 37).
[0081]
Claim 35 or the projection optical system given in 36 or 37 can have an anamorphic polynomial free sculptured surface from which power differs in a transmission type dioptric

system in a sliding direction and a longitudinal direction as "a means to amend an aspect ratio of an intermediate image of a projection object side" (Claim 38).

[0082]

It is not impossible to perform "an aspect ratio of an intermediate image" with form of a reflective mirror of a reflection type dioptric system. Howeveras for a reflective mirror of a reflection type dioptric systemit is desirable to mainly determine form focusing on distortion correction. Thereforeit is desirable that an aspect ratio can be beforehand adjusted in a transmission type dioptric systemand it is effective to use the above-mentioned polynomial free sculptured surface as a means to amend an aspect ratio by a transmission type dioptric system.

[0083]

Although adoption of a polynomial free sculptured surface to a transmission type dioptric system was not restricted to the 1st pagein an embodiment (Embodiment 6) mentioned laterthe 1st page of sufficient correction effects were acquired by transmission type dioptric system using a polynomial free sculptured surface. Although a polynomial free sculptured surface adopted as a transmission type dioptric system may be adopted as a position near a projection object sideit is preferred to adopt it as a position near the surface-of-projection sidefor heightening correction effects. Incidentally in Embodiment 6a polynomial free sculptured surface is adopted as a final surface of a transmission type dioptric system system.

[0084]

A projection optical system given in 1 with arbitrary Claims 35-38 has a preferred thing with "larger" NA by the side of a projection object side in a transmission type dioptric system than NA by the side of an intermediate image surface (Claim 39).

[0085]

When it constitutes a transmission type dioptric systemNA (it is called "NA1".) by the side of a projection object side is decided by the orientation distribution characteristic of an illumination systembut NA (it is called "NA2".) by the side of an intermediate image surface is changeable by configuration of a transmission type dioptric system. In order to make projection magnification highit is effective to strengthen power of a reflection type dioptric systembut. Since the image side focal distance of a reflection type dioptric system will become short if it does in this waya condensing point of light flux approaches the reflective mirror side of a reflection type dioptric systemtherefore only a regular image of small size can carry out image formationi.e.magnifying power becomes small. When its attention was paid to NA2 of light flux which enters into a reflection type dioptric systemand making NA2 smaller than NA1 carried out "it is highly about projection optical system magnification"it turned out [in order to clear this SUBJECT] that there is a special effect.

[0086]

in a projection optical system given in 1 with the above-mentioned arbitrary Claims 35-39 — an intermediate image surface — "— as opposed to a chief ray of light flux ejected from the center of a projection object side — inclination curve" — it can be carrying out (Claim 40). If

it does in this wayflexibility to an intermediate image surface will increase and a design of the whole optical system will become easy.

[0087]

A thing with a chief ray ejected from the center of a projection object side and a chief ray ejected from the circumference of a projection object side "almost parallel in a final surface of a transmission type dioptric system" to 1 with arbitrary Claims 35–40 in a projection optical system of a description is preferred (Claim 41).

[0088]

In a projection optical system given in 1 with arbitrary Claims 35–41a "magnification:M1 of an intermediate image is 1–5" grade is preferred (Claim 42). In a projection optical system given in 1 with arbitrary Claims 35–42the projecting magnification can be 40 or more (Claim 43). In this caseit is preferred that angle–of–projection degree:theta to a surface of projection is larger than 5 degrees (Claim 44).

[0089]

an enlargement projection optical system which carries out enlargement projection of the image of a projection object side of 0.9 inch sizes to a 60–inch screen by a diagonal line —— "–– thinness: —– it turned out that it is good for the above–mentioned NA2 to be realizing by 500–mmor less" about to 0.005 to 0.01. As for NA2since an overall length of transmission type refractive media will be extended if NA2 is made small too muchwhen it takes miniaturizing the whole equipment size into consideration0.005 to about 0.01 are desirable.

[0090]

When NA2 is made or more into 0.01transmission type refractive media become compactbut when NA becomes largethere is a tendency for reservation of distortion correction of a projection picture plane or magnification performance to become difficult. Of coursewhen screen size is smaller than 60 inches0.01 or more may be sufficient as upper limit of NA2.

[0091]

The image projection device according to claim 45 is "an image projection device which carries out extended projection of the picture displayed on a projection object side on a surface of projection according to a projection optical system"and a thing of a description was used for 1 with arbitrary Claims 35–44 as a projection optical system. This image projection device according to claim 45 can also be constituted as a front projector typeand can also be constituted as a rear projector type which has a clinch mirror which turns up an image formation optical path (Claim 46) (Claim 47). It cannot be overemphasized that an image projection device indicated to other claims is similarly made into a front projector type and a rear projector type.

[0092]

An anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal directionin the upper explanationSet a depth of the direction of Xand a curved surface to Zand let [a sliding direction (a sliding direction and a longitudinal direction are considered on the basis of a picture on which it is projected.)]

"X2Y2X2YY3and X2Y2 grade" be coefficients for the direction of Yand a longitudinal

direction

$Z=X2x^2+Y2y^2+X2Yx^2y+Y3y^3+X4x^4+X2Y2x^2y^2+Y4andy^4+$

$X4Yx^4y+X3Y2x^3y^2+Y5y^5+X6x^6+X4Y2x^4y^2+X2Y4x^2y^4+Y6andy^6+$ .. (1)

It is the form come out of and expressed.

[Effect of the Invention]

[0093]

According to this inventionlike the abovea new projection optical systeman enlargement projection optical systemenlargement projection equipmentand an image projection device are realizable.

[0094]

The projection optical system of invention indicated to 1 with arbitrary Claims 1-8Since it is constituted by the 1st and 2nd optical system and image formation of the picture formed with the light valve is carried out as an intermediate image on the optical path of the 1st and 2nd optical systemsand this intermediate image is expanded further and projectedSince it turns up in the reflector where chromatic aberration correction is possible and the 2nd optical system includes the optical path of image formation light flux using the chromatism characteristic when a color synthesizing prism is usedsince big projection magnification can be realized and the 1st optical system includes a dioptric systemit can constitute in a compact.

[0095]

Thereforethe image projection device according to claim 9 using the projection optical system of this invention can be constituted compactlyand since the optical path of image formation light flux is set in device space and it can take itit can carry out the projection display of the picture of large sizereducing the projection space besides equipment. [long]

[0096]

The enlargement projection optical system of invention indicated to 1 with arbitrary Claims 10-23 can project the picture on a picture display panel as "few big screens" on a screenand the enlargement projection equipment according to claim 24 using this enlargement projection optical system can be realized to a thin shape.

[0097]

The projection optical system indicated to 1 with arbitrary Claims 25-33When a color separation prism is used by could gather the magnifying power of composition of an optical system and having added the dioptric system to the 1st optical system by forming an intermediate image according to the 1st optical systemand carrying out extended projection by the 2nd optical systemchromatic aberration correction is possible using the chromatism characteristic. What "is made for an intermediate image to generate reverse distortion effectively so that distortion may not produce the lens element which constitutes a dioptric system in a projection image parallel eccentricity or by carrying out tilt eccentricity" is made. Thereforepoint-blank range projection is possible for the image projection device according to claim 34 at a desired magnifying power.

[0098]

A projection optical system given in 1 with arbitrary Claims 35–44 can be distorteda big screen can be projected that there is nothingand the image projection device according to claim 45 to 47 can be constituted in a thin shape.

[Best Mode of Carrying Out the Invention]

[0099]

Drawing 1 ****s the important section in one form of enforcement of the image projection device according to claim 9.

[0100]

The "light valve" shown with the mark 15 is a liquid crystal panel in this embodimentand is only hereafter called the panel 15. The light source shown with the mark 10 is constituted by the lampthe light–emitting part 11 by a reflectorand the illumination–light study system 12 that makes light flux from this light–emitting part 11 illumination luminous flux. The illumination luminous flux from the light source 10 is irradiated by the panel 15.

[0101]

the panel 15 which is a light valve embraces "modulating signal — image formation" — the picture which were formed by being carried out carries out intensity modulation of the illumination luminous flux from the light source 10 in two dimensionsand makes it penetrate Projection image formation of the light flux which penetrated the panel 15 is carried out on the screen 21 by the "projection optical system" constituted by the 1st optical system 17 and 2nd optical system 19and it displays the enlarged image of "the picture by which image formation was carried out to the panel 15."

[0102]

Drawing 2 is a figure for explaining the portion of the projection optical system in drawing 1.

[0103]

Having the 1st and 2nd optical systems 17 and 19 allocated in the projection side of the panel 15 which is a light valve 1st and 2nd sequentially from the panel 15 sidethe 1st optical system 17 has positive power by a dioptric system (lens)and the 2nd optical system 19 has a reflector which has powerand it has positive power.

[0104]

Image formation of the picture formed by the panel 15 is carried out as the intermediate image lint on the optical path of the 1st and 2nd optical systems 17 and 19and projection image formation of "the picture expanded further" is carried out in this intermediate image lint on the screen 21.

[0105]

Although the 1st optical system 17 is shown as one lens in drawing 2the composition by "various formsfor exampletwo or more lensesincluding a dioptric system"the composition which unified the lensthe combination of a mirror and a reflectorand the refracting interfaceetc. are specifically possible for it suitably.

[0106]

As the 1st optical system 17 has positive power on the whole and was shown in drawing 2the intermediate image lint formed of the 1st optical system 17 is "an inverted image of the

picture formed in the panel 15." As for the magnification of the intermediate image lintit is preferred that it is 1 to about several times the picture on the panel 15. In order to obtain "the display image of a big magnifying power" as the 1st and 2nd whole optical systems as the intermediate image lint is a reduced imagea big magnifying power is needed for the 2nd optical systemand it becomes difficult to realize amendment of aberrationetc. and balance of large magnification.

[0107]

On the contraryif the magnifying power of the intermediate image lint becomes large too muchthe size of the 2nd optical system will become large and a projection optical system and by extensionan image projection device will be enlarged.

[0108]

The optical path of the other light flux is typically shown in drawing 2 to above-mentioned position:a and b from position:A on the panel 15 corresponding to two pointsthe maximum image height (position:a in drawing 1) by the side of +and the maximum image height (position:b in drawing 1) by the side of -and B.

[0109]

The necessity of carrying out "it being image formation planate" does not necessarily have the intermediate image lintand it has just secured the performance as the whole synthetic light study system so that the picture on which it is projected on the screen 21 by the synthetic light study system of the 1st optical system 17 and the 2nd optical system 19 may turn into "a satisfying picture." Thereforethere are no restrictions in particular in the image formation performance by the 1st optical system 17.

[0110]

In the embodiment shown in drawing 1 and drawing 2the light flux to which image formation of the intermediate image lint formed of the 1st optical system 17 was carried out is reflected by the 2nd optical system 19an optical path is turned upand a projection image is projected in the direction contrary to the direction of movement of the light flux which forms the intermediate image lint.

[0111]

Although it is the example which constituted the 2nd optical system 19 from a concave mirror of the 1st page in the embodiment of drawing 1 and drawing 2the form of the 2nd optical system can include not only this but a reflector two or moreand can also include a dioptric system with a reflector.

[0112]

a page [1st more] reflector being addedinto the 2nd optical system in the composition of drawing 1 and drawing 2 -- direction of the light flux on which it is projected eventually can also be made into direction and reverse" of "drawing 1 by things. a dioptric system (lens system) being allotted as a part of 2nd optical system between the position in which the intermediate image lint is formedand the reflector 19and "light volume being incorporated more efficiently" into the reflector 19 in the composition of drawing 1 and drawing 2-- it can be made like.

[0113]
A position [in / as shown in drawing 2 / the panel 15] : the light flux on the basis of AThe position on the screen [in / it gathers so that it may have the center of gravity in position:A' in the intermediate image Iintand the beam of light after condensing spreads in the same angle of divergence as a convergence angleis reflected by the 2nd optical system 19 that has positive powerand / drawing 1] 21: Carry out image formation to a.
[0114]
The position on the position:the screen [in / it gathers so that the light flux on the basis of B may have the center of gravity in position:B' in the intermediate image Iintand the beam of light after condensing spreads in the same angle of divergence as a convergence angleis reflected by the 2nd optical system 19and / drawing 1] 21: Carry out image formation to b.
[in / similarly / the panel 15]
[0115]
What the effective area of the reflector 19 which contributes to the image formation of the light flux from position:A in the panel 15 and B "is locally narrowed for" by making the intermediate image Iint form becomes possible. Namelyas shown in drawing 2the form of "reflection region A"" of the 2nd optical system 19 influences the image formation performance to the light flux from position:Aandas for the image formation performance to the light flux from position:Bthe form of "reflection region B"" influences it.
[0116]
Thereforeit is possible to optimize the face shape of reflection region A"B" by composition shown in drawing 1 and drawing 2. On the contrarythe condensing characteristic to each part on the screen 21 becomes controllable by carrying out "changing locally" of the form of the concave surface in the 2nd optical system 19.
The effect can be efficiently employed in the maximum by making the above-mentioned concave surface into free sculptured surface form especially.
[0117]
What is necessary is just to perform optimal specifications setting out with the SHUMYU ration techniquessuch as the ray tracing method learned from the former. Since it can optimize according to a reflectorgenerating of a chromatic aberration and an increase are suppressed and the design which raises the other condensing characteristics is attained.
[0118]
Since the 1st optical system 17 includes a dioptric systemit can amend "the chromatic aberration [in a reflector] which cannot be amended" according to a dioptric system.
[0119]
The portion which cannot be amended only in the reflector of the 2nd optical system adopts a dioptric system positively to the 2nd optical systemand it may be made to amend it by several aberration which influences the projected image on which it is projected on the screen 21.
[0120]
What is necessary is just to bring the position in which the intermediate image Iint is formed

close to the reflector of the 2nd optical system 19 in the **** composition shown in drawing 1in order to raise the image formation magnification of the 2nd optical system 19. This is explained with reference to drawing 3 and drawing 4.

[0121]

In drawing 3the mark 15 shows a panelthe mark 17A shows the 1st optical system (lens)the mark 19A shows the 2nd optical system (concave mirror)and the mark 21 shows a screen.

[0122]

counting from the panel side according to the notation of the clue origin to an optical system -- the curvature radius of the i-th field -- Ri (i=1-3 i=1 -- the incident side of the 1st optical system 17A.) i= 3 sets the spacing between the reflector of the 2nd optical system 19Athe i-th fieldand the i+1st fields to Ti (i= 0-3 i= 0 between the panel 15 and the incident sides of the 1st optical system 17A and i= 3 between the 2nd optical system 19A and the screens 21).

[0123]

The clue origin to the optical system of drawing 3 is as follows.

i Ri (mm) Ti (mm) Construction material

0 85

1 65 25 BK7

2 -55 225

3 -135 -400.

[0124]

The object quantity in the panel 15 is **7.5 mm.

[0125]

The interval of each chief ray which will reach position:a on the screen 21 and b in the image height position 0 (P point on the screen 21) with position:A in the panel 15 which is an objectand B as the starting point if it sets up so that a projection image may carry out image formation the optimal is set to about 208 mm.

[0126]

As shown in drawing 4the 1st optical system 17B and 2nd optical system 19B are used hereThe power of the 1st optical system 17B is loosenedand the position of the intermediate image Iint is kept away from the 1st optical system 17Band "physical relationship has been kept so that the condensing nature in the image height 0 may be maintained" simultaneous. If the positive power in the 2nd optical system 19B is adjustedthe clue origin to these optical systems will become as the following.

i Ri' (mm) Ti'(mm) Construction material

0 85

1 65 25 BK7

2 -60 225

3 -98 -400.

[0127]

The object quantity in the panel 15 is **7.5 mm.

[0128]
Arrangement of an optical system is the same as that of drawing 3and only the curvature of the injection side of the 1st optical system 17B and the curvature of the reflector of the 2nd optical system 19B differ from the optical system of drawing 3 so that clearly [drawing 4 / drawing 4 is drawn so that drawing 3 and optical arrangement may be differedbut] from the above-mentioned clue origin on explanation.
[0129]
At this timewith position:A in the panel 15and B as the starting pointposition:a' on the screen 21 and the interval of each chief ray which reaches b' are set to about 362 mmand their magnifying power is improving rather than the case (208 mm) where it is shown in drawing 3. That isas a result of the positive power in the 1st optical system becoming weaker and the intermediate image's Iint approaching "the reflector with positive power" of the 2nd optical system 19Bmagnifying power is increasing. As mentioned abovemagnifying power can be raised only by changing the curvature radius of a refracting interface and a reflectorwithout changing optical arrangement.
[0130]
What is necessary is just to provide "an optical element with the negative power for bringing close to a reflector with positive power [in / for the image formation position of an intermediate image / the 2nd optical system]" on the optical path of the 1st and 2nd optical systems at the light-valve side of an intermediate imagein order to materialize the place explained above (Claim 2).
[0131]
In order to bring close to a reflector with positive power [in / for the position of an intermediate image / the 2nd optical system]as an optical element with the negative power provided in the light-valve side of an intermediate imagea concave lensa fresnel concave lensthe reflectors of convex shapeor these multicomputer systems can be considered.
[0132]
What is necessary is to increase the number of fields of a refracting interface or a reflectorto raise flexibility of a designand for the simulation by the ray tracing method etc. which were learned from the former just to perform an optimization designalthough it is necessary to secure the condensing characteristic in each image height positionand to amend distortion of the image surface actually.
[0133]
Drawing 5 ****s one form of implementation of the invention according to claim 3. About what is considered that there is no fear of confusion in order to avoid ****the same mark was attached also in drawing 1.
According to this embodimentthe 2nd optical system 190 has the reflector 192 which has positive powerand the reflector 191 which has negative power.
[0134]
Although it becomes image formation light flux by operation of the 1st optical system 17before carrying out image formation of the intermediate image Iintthe light flux from the

panel 15 enters into the reflector 191 with negative powerand is reflected toward the reflector 192. And the intermediate image Iint is formed in the pars intermedia of the reflector 191 and the reflector 192. The intermediate image Iint is further expanded by the positive power of the reflector 192and is projected on the picture on the panel 15 on the screen 21.

[0135]

That isthe reflector 191 in the 2nd optical system 190 is one example of "the optical system with negative power with the operation which brings the position in which the intermediate image Iint is formed close to the reflector 192 with the positive power of the 2nd optical system 190" in the invention according to claim 2.

[0136]

As the reflector 191a convex reflectorthe Fresnel convex reflectora hologram reflector with positive poweretc. can use suitably the reflected-light study element which has emission power.

[0137]

In order to separate the position of an intermediate image from a light valvesome projection optical systems cannot but become largebut by constituting the above "optical system with negative power" from a reflectorthe layout which turns up an optical path can be adopted and size of the whole optical system can be made small.

[0138]

The optical element with the negative power for bringing close to a reflector with positive power [in / for the image formation position of an intermediate image / the 2nd optical system]given in Claim 2 or Claim 3By using thisthe adjustment which narrows "the grade of emission" of the incoming beam to "a reflector with the positive power in the 2nd optical system" is attainedand it becomes possible to make small "effective reflection area" of a reflector with the above-mentioned positive power.

[0139]

The condensing characteristicdistortionetc. can be controlled more finelyadjustment of the effective reflection area of a reflector with the above-mentioned positive powerand the local shape giving of the form of the reflectori.e.setting out of free sculptured surface form.
By adoption of the composition like the abovewide angle-ization is attained from the conventional projection optical system.

[0140]

It becomes easy to carry out amendment of the increase of the flexibility of a designand several aberration by constituting the at least 1st of various kinds of reflectors explained by the upper embodiment from a free sculptured surface (Claim 4).

[0141]

It is a field where **** "free sculptured surface" includes "face shape symmetrical with non rotation"such as an anamorphic face and a X-Y polynominal sidehere.

[0142]

If all the fields (a refracting interfacea reflector) included in a projection optical system are

constituted from a free sculptured surfacethe design top can realize a very good imaging characteristicbut. Since precision prescribessuch as a relative position error of each field and an eccentric errorbecome severe actuallyit is not necessarily so good as there are many free sculptured surfacesand is good to set up the number of the optimal free sculptured surfaces.

[0143]

As explained aboveafter thatthe light flux in which the intermediate image Iint was formed turns into a sending light bunchand enters into a reflector (concave mirror) with the positive power in the 2nd optical system. Thereforeit is reflected in the local reflection region in the above-mentioned concave mirrorand image formation of the divergence light flux of each position of the intermediate image Iint is carried out on a screen. If it puts in another waythe light flux which carries out image formation to each position on a screen responds to "it is a local reflection region for every image height" in the above-mentioned concave mirror.

[0144]

making into a free sculptured surface from this face shape of the above-mentioned concave mirror (reflector where the light flux in which the intermediate image was formed is reflected in the beginning after intermediate image formation) -- "-- by adjusting the curved surface shape of a reflector to every [to each image height] reflection region"Several aberration amendment is attained most effectively and improved efficiency can be planned (Claim 5).

[0145]

As for the number of free sculptured surfacesif side machining and attachment nature are taken into considerationit is most effective to apply with the priority to the reflector (concave mirror) which has positive power immediately after the fewest possible things are good and form an intermediate image. In addition to adjustment of a reflection regionthe design which raises the characteristicssuch as the condensing characteristic and distortion of an imagemore by form setting out of "the free sculptured surface which can adjust the local form of a concave surface with condensing power" is attained.

[0146]

the magnification of an intermediate image -- "-- several [actual size -] -- what is necessary is just about [a time]"and the image formation magnification of the 1st optical system concerning formation of an intermediate image does not have a large object for **therefore can optimize the 1st optical system with the composition (Claim 6) only by a certain dioptric system from the former. If the 1st optical system is constituted only from a dioptric systemthe optical design of the 1st optical system will become easyand it will become possible to make allowable tolerance loose also about side machining or attachment nature.

[0147]

The number of refracting interfacesetc. are increased and it is also possible the increase of the flexibility of a design and to distribute and carry out improved efficiency of the common difference by that cause.

[0148]

What "the flexibility on the 1st optical system composition is further raised for" when it desires further improved efficiency although only a "dioptric system" constitutes the 1st optical system from invention according to claim 6 is needed.

[0149]

When planning such further improved efficiencyit is good to carry out "constituting from a reflector and dioptric system which have a symmetry axis of rotation inversion" of the 1st optical system (Claim 7). "The reflector with a symmetry axis of rotation inversion" is very effective in improving the flexibility of a designwithout being comparatively easy to makeattaching with processabilityand spoiling a sex. Flexibility improves further by making a reflector with this symmetry axis of rotation inversion into aspherical surface shape. The design which raised flexibility more is attained by giving the flexibility of a shift or eccentricity to this reflector.

[0150]

Aspherical surface shape can be used also in a dioptric system. By adopting such compositionthe flexibility of a design improves and a more highly efficient projection optical system can be realized.

[0151]

The various processing methodssuch as polishing work known from the formera fabricating operation by a metallic molda precise form transfer processare employable as processing of a reflector. It has composition with which the refraction transmission surface and the reflector were unitedand is good also as a total-internal-reflection structure.

[0152]

With reference to drawing 1one form of enforcement of an image projection device is explained.

As a lamp of the light-emitting part 11 in the light source 10a halogen lampa xenon lampa metal halide lampan extra-high pressure mercury lampetc. can be used.

[0153]

The reflector provided by uniting with a lamp near the lamp is used so that efficient illumination efficiency can be acquired. Although not illustrated by drawing 1it is reflected by the reflector and "light flux with directivity"The uniform Lighting Sub-Division distribution can be illuminated on a panel surface using "the publicly known illumination equalization means called an integrator optical system" so that light intensity may be equalized and it can glare on the panel 15.

[0154]

When changing to the transmission type liquid crystal panel 15 illustrated as a light valve and using "a reflection type liquid crystal light valve" for drawing 1efficient Lighting Sub-Divisionis possible by separating a lighting optical path and an incident light way using a polarization beam splitter etc.

[0155]

In using "a digital micro mirror device (DMD)" as a light valveit uses "an oblique-incidence optical system and the light-path-separation optical system using a total reflection prism."

Thusaccording to the kind of light valvea suitable optical system is employable.
[0156]
In a front type projectora projection image is shifted up and it is good to keep a projection image from becoming the shade of a projector from the viewpoint of an observer. That ishe shifts the light valve 15 (a figure under)and is trying to enter light flux from the lower part of a projection optical system in a vertical field to the optic axis (optic axis of the 1st optical system 17) of a projection optical system.
[0157]
It is necessary to take especially a large effective field angle as specification required of the 1st optical system 17so that the above-mentioned shift amount of the light valve 15 is large. The above-mentioned shift amount of the light valve 15 is set as a proper size if neededonce forms the intermediate image lint according to the 1st optical system 17and carries out enlargement projection of the picture formed with the light valve 15 on the screen 21 according to the 2nd optical system 19 that has positive power.
[0158]
In a rear pro typea flat mirror can be arranged on an incident light wayan optical path can be bentandnaturally the space share can be made smaller.
[0159]
Since it was upwards easythe one panel 15 was shownbut. After carrying out color composition of the light flux modulated by each panel by the color synthesizing means of a publicly known dichroic prism etc. using three panels for redgreenand bluea color picture cannot be projected on the screen 21 by making it enter into the 1st optical system 17 grade also until it says.
[0160]
Belowthe embodiment about the invention according to claim 10 to 24 is described.
[0161]
In the embodiment shown in drawing 6the standard beam of light of the luminous flux group which faces to the "screen" shown with the mark 2 enters into the screen 2 with the normal of the screen 2and predetermined inclination from the picture display panel (only henceforth the panel 1) shown with the mark 1. Let a "standard beam of light" be a chief ray of the light flux by which a light guide is carried out to the screen 2 from the center of the panel 1.
[0162]
The panel 1 is a reflection type liquid crystal panelit is irradiated with the illumination light which carried out linear polarization via the polarization beam splitter 10Aand the light flux modulated by the panel 1 turns into image formation light flux via the polarization beam splitter 10A.
[0163]
If the panel 1 side is called "upper stream" and the screen 2 side is called "downstream" in propagation of lightthe transmission surface which has "refracting power in the downstream of the panel 1 will be comprisedthe more than 1 page **" ****** optical system 3 will be arranged in an aspheric surfaceand the "catoptric system" which has two or more reflectors

4567and 8 in the downstream will be arranged.
[0164]
The image formation light flux from the panel 1 spreads the inside of the transmitted light study system 3and a light guide is carried out to the screen 2 via the reflectors 4–8 which constitute a catoptric system. The reflector 8 is a "rotation unsymmetrical reflector" among the reflectors 4–8 which constitute a catoptric system.
[0165]
the operation burden of magnification expansionin the transmitted light study system 3 being loosenedand "the caliber of the lens of the downstream not being enlarged" in particular in this embodimentalthough it is preferred to give a light flux condensing operation to the transmitted light study system 3 —— it is made like. Thereforein the operation of the magnification expansion as an enlargement projection optical systemthe catoptric system undertakes the all or a considerable portion.
[0166]
While the rotation unsymmetrical reflector 8 amends "an asymmetrical aberration (aberration which originates in the asymmetry in the sliding direction of the above–mentioned reference axis in a figure)"By carrying out eccentricity of the optic axis of the transmitted light study system 3and setting it up to the panel 1 (according to this embodimentthe optic axis is carrying out eccentricity to the upper part of the figure rather than the center of the panel 1)the correction effects of the asymmetrical aberration are made high. That isthe both sides of the transmitted light study system 3 and a catoptric system are made to do "sharing amendment of an asymmetrical aberration."
[0167]
The transmitted light study system 3 is attached in order to make cell–ization easy "it is a coaxis about the whole."
Like this embodimentif an enlargement projection optical system is constituted from a transmitted light study system and a catoptric systemit becomes easy to attach an optical systemthe "optical–path clinch effect" by a reflector can be harnessedand the whole system can be miniaturized rather than constituting all the optical surfaces from a reflector.
[0168]
A "diaphragm" shown with the mark 9 is provided in the upstream of the reflector 4 by the downstream of the transmitted light study system 3and the image I9 of the diaphragm 9 carries out image formation on an image formation optical path with "negative reducing magnification" according to the reflector of the downstream from the diaphragm 9. That isimage formation of the "image I9 of reducing magnification" of the diaphragm 9 is carried out as an inverted image between the reflector 7 and the rotation unsymmetrical reflector 8 by operation of the reflectors 456and 7 of a catoptric system.
[0169]
Thussince the light flux which enters into the reflector (the embodiment under explanation reflector 8) which is in the downstream from the image I9 of the diaphragm 9 will not spread greatly if power arrangement in which the image I9 of the diaphragm 9 carries out image

formation with reducing magnification is takenthis reflector can be made small.
[0170]
Like ****image formation of the image I9 of the diaphragm 9 is carried out within the optical path of a catoptric system (between the reflector 7 and the rotation unsymmetrical reflectors 8)and this image formation position becomes "the pupil by the side of a screen"i.e.the "exit pupil" of an enlargement projection optical system.
[0171]
On the optical path within a catoptric systemimage formation light flux carries out image formation of the intermediate image of the panel 1. This intermediate image is statues ["real image / of negative magnification"] like the image I9 of the diaphragm 9. According to the embodiment shown in a figureimage formation of the intermediate image of the panel 1 is carried out near the reflector of the reflector 7. That isthe intermediate image of the panel 1 is formed of the transmitted light study system 3 and the reflectors 4–6.
[0172]
The enlarged image by the reflector 7 and the rotation unsymmetrical reflector 8 of an intermediate image of the panel 1carries out image formation to the screen 2and the image formation magnification at this time is also negative. Thusimage formation of the light flux from the panel 1 is carried out as statues [intermediate image]and image formation is carried out on the screen 2 as an erect image in which this ****** did a handstand further. In that casethe keystone distortion generated in an intermediate image can set off against a keystone distortion in case image formation is carried out on a screenand can suitand a display image with few keystone distortions can be obtained.
[0173]
If the transmitted light study system 3 is cell–ized as one unitas positioning in an enlargement projection optical systemrelative positioning of the transmitted light study system 3 and catoptric system which were cell–ized will be left behind. When the light flux ejected from the transmitted light study system 3 at this time as the power of the reflector 4 by the side of the top style in a catoptric system is positive is a condensed light bunchthis light flux receives the operation further condensed by the positive power of the reflector 4.
[0174]
In this embodimentpower of the reflector 4is made negative. If power of the reflector 4 is just carried outthe aberration which the relative position of the transmitted light study system 3 and a catoptric system generates at the time of "gap" ** will become large. When it puts in another wayand the amount of gaps of the transmitted light study system 3 and a "catoptric system" is the samethe variation of aberration to the amount of gaps is large.
[0175]
Like an embodimentwhen power of the reflector 4 is made negativethe above "variation of aberration to the amount of gaps" is small. Thereforethe accuracy of the relative physical relationship of the transmitted light study system 3 and a catoptric system becomes looseand it becomes easy to optical system attach it.
[0176]

After making power of the above-mentioned reflector 4 negativethe power of the reflector 5 arranged in the lower stream serves as positive. If the reflector of negative power continuesit becomes impossible for the divergence of an incoming beam to become excessive and to carry out image formation of "the image of a diaphragm" into a catoptric system in the upstream in a catoptric system.

[0177]

It is important to make power of the reflector 5 positivewhen making into a convergence tendency image formation light flux reflected by the reflector 5 and carrying out image formation of the image I9 of the diaphragm 9 into the optical path of a catoptric system. That isthe synthesis power of the optical system (reflectors 4-7) established between the images I9 of the diaphragm by the diaphragm 9 is positive.

[0178]

Although the reflector 5 may also be made into negative power with the reflector 4 and power of the reflector 6 of the downstream may just be carried outsince the necessity of strengthening power of the reflector 6 arisesor an end-to-end dimension becomes longan aberration yield increasesan optical system becomes large and the number of constituent faces also increasesthere is no merit not much.

[0179]

In the enlargement projection optical system to which both the panel 1 and the screen 2 carry out "slanting projection" at a flat surfaceIn this inventionThe intermediate image of negative magnification of the panel 1 which the other light flux generates from the panel 1 side to the screen 2The optical system of the upstream of an intermediate image surface and the downstream is constituted so that the position and form of "the intermediate image of negative magnification of the screen 2 which the other light flux generates from the screen 2 side to the panel 1" may be abbreviated-in agreement.

[0180]

It is the other light flux from the screen 2 side to the panel 1says the virtual light flux used when it makes a panel the image surface by making a screen into an object face in the case of an enlargement projection optical system design and ray tracing is performed.

[0181]

In a catoptric system partthe rotation unsymmetrical reflector 8 has a preferred thing [as / in this embodiment] arranged in the position nearest to the screen 2 of the lowest style on the optical path of image formation light flux. The field overlapping in the upper stream of the incidence position of "each light flux corresponding to a different field angle" in the reflectors 4-8 is largeand it is made for its "field with which it laps" to decreaseso that it goes downstream.

[0182]

Since the flexibility of the face shape which can be taken to an incidence position is higha rotation unsymmetrical reflectorIf the rotation unsymmetrical reflector 8 is carried out the lowest style side and it is made for "the field with which each light flux corresponding to a different field angle laps mutually" to decrease in this surface positionRather than the

rotation unsymmetrical reflector 8the face shape suitable for amendment of the residual aberration which the light flux of each field angle hasby the optical system of the upstream can be given to the rotation unsymmetrical reflector 8and the high aberration compensation effect can be realized.

[0183]

Contrary to the aboveif a rotation unsymmetrical reflector is established in the upstream of a catoptric systemsince it will be in "the state where the light flux of a different field angle has lapped and entered" in the homotopic of the reflectorit will become difficult to acquire "the form solution to a reflector" which amends simultaneously the aberration which each of the light flux of a different field angle has.

[0184]

Amendment of an asymmetrical aberration ingredientcan be made to share also with the transmitted light study system 3 in this embodiment. in such a case -- for making correction effects high -- the transmitted light study system 3 -- "rotation -- unsymmetrical transmission surface" is given. The rotational asymmetrical surface is effective in carrying out "amending the aberration component in which amendment is difficult in a symmetry-of-revolution aspheric surface."

[0185]

Although the catoptric system comprises two or more reflectors 4-8by constituting in one by making these into a unitit becomes easy to take out the relative position precision of reflectorsand attachment of an enlargement projection optical system becomes easy. Although unification of a reflector is realizable by for examplea molding methodit may realize not only by this but by other proper methods.

[0186]

If it adds a littlethe position which arranges the diaphragm 9 may be provided not only in the position of drawing 1 but in face-to-face [in / for example/ the transmitted light study system 3]. In this casea part of transmitted light study system will participate in the image formation of the image of a diaphragm.

[0187]

A picture display panel displays each color component image of R (red)G (green)and B (blue) on a different picture display panel for every color using the picture display panel of not only one sheet but three sheetsand compounds the light from these picture display panelsA light guide can be carried out to a screen according to an enlargement projection optical systemand it can also constitute so that a color picture may be displayed on a screen.

[0188]

In such a casein drawing 1what combined the polarization beam splitter and impounding basin ROIKU prism between the panel 1 and the transmitted light study system 3 (in the color picture projection deviceknown widely) can be used.

The screen may not necessarily be a flat surface.

[0189]

As explained abovethe enlargement projection optical system which shows drawing 1 an

embodimentCarry out the light guide of the light flux from the picture display panel 1 to the screen 2and it projects from the direction inclined to the normal of the screen 2It is an enlargement projection optical system to which image formation of the enlarged image of the picture displayed by the picture display panel 1 on the screen 2 is carried outIt has the catoptric systems 4–8 and the transmitted light study system 3and a catoptric system is constituted by two or more reflectors 4–8 with powerand including the rotation unsymmetrical reflector 8the transmitted light study system 3 is constituted by the transmission surface with refracting powerand includes the 1st [or more] page of an aspheric surface (Claim 10).

[0190]

It extracts from the picture display panel side in the transmitted light study system 3 between the 1st page and the screen side in a catoptric systemand the 1st pageand 9 is providedand it is constituted by the optical elements 4–7 arranged to the screen side so that the image I9 of the diaphragm 9 may carry out image formation with negative reducing magnification (Claim 11).

[0191]

The transmitted light study system 3 which the enlargement projection equipment of drawing 1 becomes from two or more transmission surfaces againThe inside of a reflector [in / it has a catoptric system which comprises two or more reflectors 4–8and the diaphragm 9and / a catoptric system]The power of the reflector 4 in which the light flux which passed the diaphragm 9 has the power which enters first is negative (Claim 12)The light flux which passed the diaphragm 9 has positive power (Claim 13)and the reflector 5 following the reflector 4 with the negative power which enters first a catoptric systemConstituted by two or more reflectors 4–8 with powerincluding the rotation unsymmetrical reflector 8the transmitted light study system 3 is constituted by the transmission surface with refracting powerand includes the 1st [or more] page of an aspheric surface (Claim 14).

[0192]

The intermediate image of the negative magnification of the picture display panel in which the light flux from the picture display panel 1 side to the screen 2 generates the enlargement projection optical system of drawing 1 againThe catoptric systems 4–8 to which the position and form of the intermediate image of the negative magnification of the screen 2 which the light flux from the screen 2 side to the picture display panel 1 generates are abbreviated–in agreement (Claim 15)and changes from two or more reflectorsHave the transmitted light study system 3 which consists of two or more transmission surfaces (Claim 16)and it has the diaphragm 9The power of the reflector 4 in which the light flux which passed the diaphragm among the reflectors in a catoptric system has the power which enters first is negative (Claim 17)The reflector 5 following the reflector 4 in which the light flux which passed the diaphragm 9 has the negative power which enters first has positive power (Claim 18)A catoptric system is constituted by two or more reflectors with powerand including the rotation unsymmetrical reflector 8the transmitted light study system 3 is constituted by the transmission surface with refracting powerand includes the 1st [or more] page of an

aspheric surface (Claim 19).
[0193]
The rotation unsymmetrical reflector 8 is arranged in an incident light on the street "it is the screen 2 side most" (Claim 20)the rotation in which the transmitted light study system 3 has refracting power — an unsymmetrical transmission surface is included (Claim 21)and to the position of the picture display panel 1in the field including a light guide optical paththe optic axis of the transmitted light study system 3 carries out eccentricityand is set up (Claim 22). A catoptric system can be constituted in one as a unit (Claim 23).
[0194]
Thereforeby adding various kinds of publicly known light sources to drawing 6 to the enlargement projection optical system which showed the embodimentDisplay a picture on the picture display panel 1illuminate the picture display panel 1 with the light from a light sourcecarry out the light guide of the light flux from the illuminated picture display panel 1 to the screen 2 according to an enlargement projection optical systemand it projects from the direction inclined to the normal of the screen 2It is enlargement projection equipment which projects the enlarged image of the picture displayed by the picture display panel 1 on the screen 2and the enlargement projection equipment (Claim 24) using the enlargement projection optical system of the description can be realized to 1 with Claims 9–23 arbitrary as an enlargement projection optical system.
[0195]
Hereafterthe embodiment of the invention according to claim 25 to 34 is described.
[0196]
Drawing 7 shows one form of the enforcement of an image projection device which has the projection optical system according to claim 25. The portion of a projection optical system is expanded and it is shown in drawing 8.
[0197]
In drawing 8the 1st optical system matched for the object side with the portion shown with the mark 71 and the portion which shows with the mark 72 show the 2nd optical system allotted to the image side. The 1st optical system 71 comprises the lenses 711–716is extracted immediately after the lens 713and has S. The lens 713 is a "cemented lens." The marks 721 and 722 show the page [2nd] reflector which constitutes the 2nd optical system.
[0198]
As [explained / the object side of the 1st optical system 71 / to drawing 6 / based and] "to a reflection type liquid crystal panel. It irradiates with the illumination light which carried out linear polarization via a polarization beam splitterthe thing of the mold with which the reflected light flux modulated with the liquid crystal panel turns into image formation light flux via a polarization beam splitter" is assumedand the mark PB shows the "polarization beam splitter."
[0199]
Although the light flux from the object side projects a picture on the surface of projection (screen shown in drawing 7) which is not illustrated via the 1st optical system 71 and the 2nd

optical system 72image formation of the objective intermediate image is carried out to the position between the reflectors 721 and 722and image formation is carried out as a regular image on a surface of projection according to the reflector 722.

[0200]

As "an object which displays the picture on which it should be projected"the thing of composition of illuminating the light flux from the light-emitting part 11 according the light valve 15 to a lamp and a reflector by the illumination-light study system 12based and shown in drawing 1 can be used again. As an example of a light-emitting parta halogen lampa xenon lampa metal halide lampan extra-high pressure mercury lampetc. are preferred. "The integrator optical system which equalizes the intensity of the light flux which was reflected by the reflector and had directivity to a light valve" can also be carried in an illumination-light study system.

[0201]

As the above-mentioned objectto the DMD panelit is a "oblique-incidence optical system" and a total reflection prismand the thing of a system which performs light path separation can also be used again. Of coursethe self-luminescence type object of an LED arrayEL arraya plasma displayetc. can also be used.

[0202]

Namelythe projection optical system in the embodiment shown in drawing 7 and drawing 8The 1st optical system 71 that has positive power including at least one dioptric system (lens 711 grade)It has the 2nd optical system 72 that has positive power on the whole including at least one reflector (721st grade) which has powerAre arranged in order of the 1st and 2nd optical system from the side near an object faceand it is constituted so that image formation may be carried out as a regular image once an object image is formed as an intermediate imageas opposed to the optic axis of the optical element 711 which had the refracting power nearest to the object side in the 1st optical system -- other optical elements 712-716721and 722 --- parallel eccentricity -- and/ortilt eccentricity is carried out (Claim 25).

[0203]

The composition about Claims 26-34 is later mentioned as a concrete embodiment.

[0204]

One form of the enforcement of an image projection device which has the projection optical system according to claim 35 is shown in drawing 12. The portion of the projection optical system is expanded and shown in drawing 13.

The portion shown with the mark 100 was based and explained to drawing 6 in drawing 13 "to a reflection type liquid crystal panel. The reflected light flux which irradiated with the illumination light which carried out linear polarization via the polarization beam splitterand was modulated with the liquid crystal panel 1 is an object side portion of the mold which serves as image formation light flux via a polarization beam splitter"and the picture display surface of a reflection type liquid crystal panel is a "projection object side." The mark PB shows a polarization beam splitter among a figure. The composition by the side of an object was based and explained not only to this but to drawing 1 "the light valve 15The thing of

composition of illuminating the light flux from the light-emitting part 11 by the lamp and a reflector by the illumination-light study system 12Can also use or the thing which added the integrator optical system to this"andThe thing of a system which performs light path separation with an oblique-incidence optical system or a total reflection prism to the DMD panel can also be usedand the self-luminescence type object of an LED arrayEL arraya plasma displayetc. can also be used.

[0205]

The portion which the portion shown with the mark 120 shows a "transmission type dioptric system"and is shown with the mark 130 is a "reflection type dioptric system."

[0206]

The transmission type dioptric system 120 is constituted by the lenses 121-127. The lens 123 and the lens 126 are cemented lensesand the whole comprises nine lenses. The reflection type dioptric system 130 consists of the 1st reflective mirror 131 (only a reflector is shown.) and the 2nd reflective mirror 132 (only a reflector is shown.).

[0207]

Namelyin the projection optical system shown in drawing 12 and drawing 13. On the surface of projection which is not illustrated via the transmission type dioptric system 120 and the reflection type dioptric system 130 which comprises the two reflective mirrors 131 and 132 arranged 1st and 2nd sequentially from this transmission type dioptric system sidethe light guide of the light flux from a projection object side is carried outand it is projected.

[0208]

The transmission type dioptric system 120 has two or more transmission type refraction elements 121-127and like a graphic display a projection object side to the 1st page (object side of the lens 121) of a transmission type dioptric systemit was shown in the figure -- as -- "-- it is abbreviation tele centric"and the intermediate image surface of a projection object side is located between the two reflective mirrors 131 and 132 in the reflection type dioptric system 130and re-image formation of the intermediate image in an intermediate image surface is carried out as a regular image on a surface of projection via the 2nd reflective mirror 132.

[0209]

As shown in the embodiment (embodiment 6) mentioned laterthe 1st reflective mirror 131 is a reflector symmetrical with the axis of negative powerThe 2nd reflective mirror 132 is "an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction" (Claim 37)to the normal of a surface of projectionthe beam of light which reaches the surface of projection which is not illustrated from the 2nd reflective mirror 132 inclinesand a light guide is carried out.

[0210]

And although eccentricity of the transmission type dioptric system 120 is carried out to the normal of a projection object sidetwo or more transmission type refraction elements 121-127 which a transmission type dioptric system has are constitutedwithout carrying out eccentricity mutually.

[0211]
although the lens 123 and the lens 126 are cemented lenses and these cemented lenses 123 and 126 constitute the "group unit" of a lensrespectively — these cemented lenses — "— without it carries out eccentricity mutually on a group unit level — composition" — it is carried out (Claim 36).
[0212]
carry out [to the chief ray of the light flux ejected from the center of a projection object side / an inclination curve]The image surface of the intermediate image by which image formation is carried out among the reflective mirrors 132 and 133 is so that drawing 13 may show (Claim 40)In the final surface (injection side of the lens 127) of a transmission type dioptric systemit is "almost parallel [the chief ray ejected from the center of the projection object sideand the chief ray ejected from the circumference of the projection object side]" (Claim 41).
[0213]
Although the image projection device of drawing 12 is a "front projector type" (Claim 46)it can be considered as a "rear projector type" byof course adding the reflector which bends an optical path in an image formation optical path (Claim 47).
[0214]
Hereaftera concrete embodiment is given.
In the specifications of an optical systema surface number item considers it as a page [0th] object face (field where the picture on which it should be projected is displayed)and counts the 1st page with .. the 2nd page one by one below. The 1st page and the 2nd page are fields by the side of the liquid crystal panel of a "polarization beam splitter"and a projection optical system through all the embodiments.
[Work example 1]
[0215]
Embodiment 1 is a concrete embodiment of the image projection device and projection optical system shown in drawing 7 and drawing 8 previously. Namelythe 1st optical system 71 that has positive power including at least one dioptric systemIt has the 2nd optical system 72 that has positive power on the whole including at least one reflector which has powerAre arranged in order of the 1st and 2nd optical system from the side near an object faceand it is constituted so that image formation may be carried out as a regular image once an object image is formed as an intermediate imageas opposed to the optic axis of the optical element 711 which had the refracting power nearest to the object side in the 1st optical system — other optical elements 712–716721and 722 — parallel eccentricity — and/ortilt eccentricity is carried out.
Magnifying power of an intermediate image is about 3 times.
[0216]
Specifications of Embodiment 1 are shown in Table 1.
[0217]
[Table 1]

[0218]
In Table 1it shows the amount of tilt eccentricity that there is that it is with a shift with the amount of shift eccentricity and a tilt. A unit of "mm" and the amount of tilt eccentricity of a unit of a curvature radiusa spacingand the amount of shift eccentricity is a "degree." Also in each following embodimentit is the same.
[0219]
Although a reflector of the 2nd reflective mirror that is the 18th page is "an anamorphic polynomial free sculptured surface from which power differs in a sliding direction and a longitudinal direction" shown by the above-mentioned formula (1)a coefficient in this polynomial free sculptured surface is mentioned to Table 2.
[0220]
[Table 2]

[0221]
In the above-mentioned notation1.14641E-11means "1.14641×10^{-11}." It is the same as that of below.
[0222]
Although the 1st optical system is constituted by seven lenses and the 2nd optical system comprises a page [2nd] reflector like the abovethe reflector 721 is a surface of a sphereand the reflector 722 is a polynomial free sculptured surface.
[0223]
Although the image surface (screen) of a regular image is a flat surface parallel to the longitudinal direction of drawing 7Although the difference of the angle which enters into a screen tended to come by the low position (side near an object) of image heightand the high position (side far from an object) in size and tended to become a sake "bent projection image in which the bottom becomes narrower" in themdistortion of an intermediate image was set up conversely and distortion by a final image surface was amended.
[0224]
The state of distortion of an imagein the final image surface is shown in drawing 11. Drawing 11 shows the situation of distortion when the picture as which the liquid crystal panel of 0.9 inch of diagonal:abbreviation is displayed is expanded to about 60 inches and projected on a screen. As shown in a figureit turns out that the image of a grid can be formed in abbreviation regular intervalsand the keystone distortion is amended good. Projection sizes are 1200 mm x 900-mm sizemagnifying power is 65 or more timesand distortion is dramatically good at 0.5% or less.
[Work example 2]

[0225]
Embodiment 2 is a concrete embodiment of the image projection device and projection optical system shown in drawing 9. Drawing 9 expands and shows the projection optical system portion of the image projection device.
[0226]
The 1st optical system 81 is constituted by the six lenses 811–816and the 2nd optical system 82 is constituted by the reflectors 821 and 822 of two sheets. The diaphragm which is not illustrated is arranged between the lens 813 and the lens 814.
[0227]
An intermediate image is formed in the middle of the reflectors 821 and 822 as an inverted image of the 1st optical system 81 like Embodiment 1. The reflector 821 which has the positive power which reflects first the light side which entered into the 2nd optical system 82 was made into aspherical surface shape symmetrical with rotationand made the reflector 822 the polynomial free sculptured surface. It is the example whose higher design of flexibility was attained by adoption of aspherical surface shape symmetrical with rotation.
[0228]
The specifications of Embodiment 2 are shown in Table 3.
[0229]
[Table 3]

[0230]
The aspheric surface of the rotation object used for the 16th page is an aspheric surface type of the well–known which makes a paraxial curvature radius and r the distance of the optic–axis direction crossing at a right angle from an optic axisand makes [Z / a cone constantABC..etc.] k a high order aspheric surface coefficient for the depth of an optical axis directionand c. :
$Z=c$ and $r^2/[1+root\{1-(1+k)\ c^2r^2\}]+Ar^4+Br^8+Cr^8$
It is alikeit setskABand C are givenand form is specified. Also in other following embodimentsit is the same.
[0231]
The coefficient of a page [16th] aspheric surface is given to Table 4.
[0232]
[Table 4]

[0233]
The value of the coefficient of a page [17th] polynomial free sculptured surface is given to Table 5.

[0234]
[Table 5]

[Work example 3]
[0235]
Embodiment 3 is a concrete embodiment of the image projection device and projection optical system shown in drawing 10.
The 1st optical system 91 is constituted by the five lenses 911–915and the 2nd optical system 92 is constituted by the reflectors 921 and 922 of two sheets. The lens 913 is a cemented lens. The diaphragm which is not illustrated is arranged between the lens 913 and the lens 914.
[0236]
An intermediate image as well as Embodiments 1 and 2 is formed in the middle of the reflectors 921 and 922. An intermediate image is formed as an inverted image of the 1st optical system. The reflector 921 which has the positive power which reflects first the light side which entered into the 2nd optical system is spherical surface shapeand the reflector 922 is a polynomial free sculptured surface.
[0237]
The specifications of Embodiment 3 are shown in Table 6.
[0238]
[Table 6]

[0239]
The tilt of the 1st page (in Table 6it is the 3rd page) of the lens 911 is carried out 2.2 degrees so that clearly from Table 6but tilt eccentricity of the lenses 912–915 is not carried out to the optic axis of this lens 911but it is only carrying out parallel eccentricity of the lenses 911–915 to the optic axis of the lens 911. As for a dioptric systemthis acts as one group including 1 set of cemented lenses 913.
[0240]
The value of the coefficient of a page [16th] polynomial free sculptured surface is shown in Table 7.
[0241]
[Table 7]

[Work example 4]

[0242]
Embodiment 4 changes specifications with the same optical system composition (drawing 10) as Embodiment 3 given upwards.
[0243]
The specifications of Embodiment 4 are shown in Table 8.
[0244]
[Table 8]

[0245]
A value of a coefficient of a page [16th] polynomial free sculptured surface is shown in Table 9.
[0246]
[Table 9]

[Work example 5]
[0247]
Specifications are changed with the optical system composition (drawing 10) as Embodiment 3 given upwards also with same Embodiment 5.
[0248]
Specifications of Embodiment 5 are shown in Table 10.
[0249]
[Table 10]

[0250]
A value of a coefficient of a page [16th] polynomial free sculptured surface is shown in Table 11.
[0251]
[Table 11]

[0252]
The 1st optical system in which the above-mentioned Embodiments 1-5 have positive power including at least one dioptric system as mentioned aboveIt has the 2nd optical system that has positive power on the whole including at least one reflector which has powerAre

arranged in order of the 1st and 2nd optical system from the side near an object faceand it is constituted so that image formation may be carried out as a regular image once an object image is formed as an intermediate imageIn one or more places to the optic axis of an optical element which had the refracting power nearest to the object side in the 1st optical system other optical elementsEach element of the 1st optical system 91 has not carried out tilt eccentricity to parallel eccentricity and/or the optic axis of the optical element 911 which is carrying out tilt eccentricity (Claim 25) and had the refracting power nearest to the object side in the 1st optical system 91 in Embodiments 3-5 (Claim 26).

[0253]

In Embodiments 3-4the 1st optical system 91 comprises two or more groupsand the lens 913 which makes one group as a cemented lens of the two or more groups is carrying out parallel eccentricity (Claim 27).

[0254]

One or more [of the reflector where Embodiments 1-5 are included in the 2nd optical system] is a free sculptured surface (Claim 28)Only the reflector nearest to the image formation position side of a regular image among the reflectors included in the 2nd optical system is a free sculptured surface (Claim 29)and in Embodiments 1-5. The light flux which entered into the 2nd optical system is a field where the reflector which has the first positive power to be reflected is symmetrical with rotation (Claim 30)and a reflector symmetrical with the above-mentioned rotation is a surface-of-a-sphere reflector in Embodiments 13-5 (Claim 31).

[0255]

The 1st optical system comprises only a dioptric system for Embodiments 1-5 (Claim 32)and aspherical surface shape is not included in the dioptric system in the 1st optical system (Claim 33).

[0256]

Thereforethe image projection device which combined the object with the projection optical system of the above-mentioned embodiment constitutes the concrete embodiment of the image projection device according to claim 34.

[0257]

Next Embodiment 6 is a concrete embodiment of the projection optical system and image projection device which was based on drawing 12 and drawing 13 and described the embodiment previously.

[0258]

The specifications of Embodiment 6 are shown in Table 12.

[0259]

[Table 12]

[0260]

The coefficient of an aspheric surface (the 7th page and the 15th page) is given to Table 13.
[0261]
[Table 13]

[0262]
The value of the coefficient of a polynomial free sculptured surface (the 19th page and the 21st page) is given to Table 14.
[0263]
[Table 14]

[0264]
the MTF performance on the screen by the projection optical system of Embodiment 6 --- frequency: --- in 0.5c/mmdistortion is 2% or less not less than 60%.
The size of the screen which projects a regular image in Embodiment 6 is 60 inchesand "the maximum width of the direction which intersects perpendicularly with a screen" of a projection optical system is 472 mm.
[0265]
In [as shown in drawing 14] the direction (longitudinal direction) of Xand the direction (sliding direction) of Y on a screenWhen the line of the shape of a go board of **1.0Y**0.5Y0.0Y**1.0X**0.5Xand 0.0X was set up and the MTF value to evaluation frequency:0.5c/mm was investigatedit becameas shown in Table 15.
[0266]
[Table 15]

[0267]
The MTF characteristic of the sagittal direction (s) in **1.0Y in the range of frequency:0 in X=0.0X - 0.5c/mm and 0.0Y and the meridional direction (m) is shown in drawing 15. The MTF characteristic of the sagittal direction (s) in **1.0Y in the range of frequency:0 in X=0.5X - 0.5c/mm and 0.0Y and the meridional direction (m) is shown in drawing 16. The MTF characteristic of the sagittal direction (s) in **1.0Y in the range of frequency:0 in X=1.0X - 0.5c/mm and 0.0Y and the meridional direction (m) is shown in drawing 17. Embodiment 6 has the good MTF characteristic so that clearly from these figures.
[0268]
The projection optical system of Embodiment 6 has two reflective mirrors by which a ****** type dioptric system is arranged 1st and 2nd sequentially from the transmission type dioptric

system sideThe intermediate image surface of a projection object side is located between the above 1st and the 2nd reflective mirrorThe reflector (the 22nd page) where the 1st reflective mirror is symmetrical with the axis of negative powerand the 2nd reflective mirror are anamorphic polynomial free sculptured surfaces (the 23rd page) from which power differs in a sliding direction and a longitudinal direction (Claim 37)It has an anamorphic polynomial free sculptured surface (the 19th page) from which power differs in a transmission type dioptric system in a sliding direction and a longitudinal direction as a means to amend the aspect ratio of the intermediate image of a projection object side (Claim 38).

[0269]

NA (=0.143) by the side of the projection object side in a transmission type dioptric systemMore greatly (Claim 39) than NA (=0.01) by the side of an intermediate image surfacemagnification:M1 (=1.5) of an intermediate image is in the range of 1-5 (Claim 42)projecting magnification (= 75 times) is 40 or more (Claim 43)and angle-of-projection degree:theta (= 11 degrees) to a surface of projection is larger than 5 degrees (Claim 44).

[Brief Description of the Drawings]

[0270]

[Drawing 1]It is a figure for explaining a projection optical system and one form of enforcement of an image projection device.

[Drawing 2]It is a figure for explaining the projection optical system of the embodiment shown in drawing 1.

[Drawing 3]It is a figure for explaining the invention according to claim 2.

[Drawing 4]It is a figure for explaining the invention according to claim 2.

[Drawing 5]It is a figure for explaining the invention according to claim 3.

[Drawing 6]It is a figure for explaining one form of enforcement of an enlargement projection optical system.

[Drawing 7]It is a figure for explaining one form of enforcement of an image projection device.

[Drawing 8]It is a figure expanding and showing the projection optical system portion in drawing 7.

[Drawing 9]It is a figure for explaining another form of enforcement of an image projection device.

[Drawing 10]It is a figure for explaining other forms of enforcement of an image projection device.

[Drawing 11]It is a figure showing the state of the distortion on the screen in Embodiment 1.

[Drawing 12]It is a figure for explaining other forms of enforcement of an image projection device.

[Drawing 13]It is a figure expanding and showing the projection optical system portion in drawing 12.

[Drawing 14]It is a figure for explaining the evaluation point of MTF on the screen about Embodiment 6.

[Drawing 15]It is a figure showing the MTF characteristic about Embodiment 6.

[Drawing 16]It is a figure showing the MTF characteristic about Embodiment 6.

[Drawing 17]It is a figure showing the MTF characteristic about Embodiment 6.

[Explanations of letters or numerals]

[0271]

L1 The 1st lens

L2 The 2nd lens

L3 The 3rd lens

1 Picture display panel

2 Screen

3 Transmitted light study system

4–8 Reflector which constitutes a catoptric system

8 Rotation unsymmetrical reflector

9 Diaphragm

I9 The image of a diaphragm

DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]

[0270]

[Drawing 1]It is a figure for explaining a projection optical system and one form of enforcement of an image projection device.

[Drawing 2]It is a figure for explaining the projection optical system of the embodiment shown in drawing 1.

[Drawing 3]It is a figure for explaining the invention according to claim 2.

[Drawing 4]It is a figure for explaining the invention according to claim 2.

[Drawing 5]It is a figure for explaining the invention according to claim 3.

[Drawing 6]It is a figure for explaining one form of enforcement of an enlargement projection optical system.

[Drawing 7]It is a figure for explaining one form of enforcement of an image projection device.

[Drawing 8]It is a figure expanding and showing the projection optical system portion in drawing 7.

[Drawing 9]It is a figure for explaining another form of enforcement of an image projection device.

[Drawing 10]It is a figure for explaining other forms of enforcement of an image projection device.

[Drawing 11]It is a figure showing the state of the distortion on the screen in Embodiment 1.

[Drawing 12]It is a figure for explaining other forms of enforcement of an image projection device.

[Drawing 13]It is a figure expanding and showing the projection optical system portion in drawing 12.

[Drawing 14]It is a figure for explaining the evaluation point of MTF on the screen about

Embodiment 6.

[Drawing 15]It is a figure showing the MTF characteristic about Embodiment 6.

[Drawing 16]It is a figure showing the MTF characteristic about Embodiment 6.

[Drawing 17]It is a figure showing the MTF characteristic about Embodiment 6.